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Lung Cancer Screening with Low-Dose Computed Tomography for Primary Care Providers

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Abstract

This review provides an update on lung cancer screening with low-dose computed tomography (LDCT) and its implications for primary care providers. One of the unique features of lung cancer screening is the potential complexity in patient management if an LDCT scan reveals a small pulmonary nodule. Additional tests, consultation with multiple specialists, and follow-up evaluations may be needed to evaluate whether lung cancer is present. Primary care providers should know the resources available in their communities for lung cancer screening with LDCT and smoking cessation, and the key points to be addressed in informed and shared decision-making discussions with patients.

Keywords

Lung neoplasms; Screening; Computed tomography; Primary health care; Practice guidelines; Smoking cessation; Shared decision making

POPULATION MEASURES OF LUNG CANCER

Occurrence

Each year in the United States 206,000 people are told that they have lung cancer, and 160,000 die of this disease.[1] Lung cancer represents 14% of all invasive cancers diagnosed each year and 28% of all cancer deaths in the United States population.[1] The overall 5-year relative survival of patients with lung cancer is less than 18%.[2] More than half of lung cancers have distant metastasis at the time of diagnosis, and the 5-year relative survival after

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distant metastasis is less than 5%.[2] The average life expectancy of a patient with lung cancer is shortened by about 14 years.[3]

Cost

The total national cost of lung cancer care in 2010 was estimated at more than US$12 billion, and the cost could grow to exceed $18 billion by the year 2020.[4] The deductibles and copays incurred by individual patients with lung cancer can exceed well over $1000 per month.[5] Lung cancer screening with low-dose computed tomography (LDCT) at the patient's own expense can result in decreased intention to undergo screening and a lower adherence to attend an annual follow-up.[6] Some health care facilities have developed initiatives to provide the initial examination for lung cancer screening with LDCT at no cost to the patient.[7] National estimates of additional annual health expenditures related to lung cancer screening are still in the early stages, make different assumptions, and have come to varying conclusions.[8–12] The costs of an initial LDCT examination for lung cancer screening have been advertised at $99 to $1000.[13] The additional costs associated with follow-up evaluation and the treatment of abnormalities can be substantial; the implementation of lung cancer screening with LDCT has been estimated to increase the annual national health care expenditures by $1.3 to $2.0 billion if the screening rates were to reach 50% to 75% among those eligible for screening.[11]

Patterns Across Age, Sex, and Time

During the period 2005 to 2009, the incidence of lung cancer in the United States was highest among those aged 75 years and older, and decreased with decreasing age.[14] In all age groups except persons younger than 44 years, incidence rates of lung cancer were higher among men than among women; this difference being greatest among those aged 75 years and older, and narrowed with decreasing age.[14] In men, age-adjusted death rates for lung cancer increased until 1990 and then began to decrease.[15,16] In women, age-adjusted death rates for lung cancer peaked in 2004 and have had a lower rate of decline than for men.[16] These trends in incidence and mortality are thought to reflect changes in smoking patterns over time.[17,18]

Disparities

Disparities exist in the incidence and death rates of lung cancer within the United States population by race, ethnicity, and geography. Among men, the incidence and death rates are highest among blacks than among other racial and ethnic groups.[1] Among women, the incidence and death rates are similar between whites and blacks and highest among whites in comparison with other groups.[1] At all ages for both men and women, Asian and Pacific Islanders and Hispanics have lower incidence and death rates than other groups.[1] Incidence of lung cancer varies between states,[14,19] and is highest in the South and lowest in the West.[20] Large geographic differences have been demonstrated in incidence rates of lung cancer for American Indian and Alaska Native populations, with the highest rates in the Plains and Alaska.[21] Research suggests that multiple factors may be associated with tobacco use, including socioeconomic status, education, cultural beliefs, and environmental influences.[22–24] Differences in the prevalence of exposures to other carcinogens and risk factors may also explain some of the observed differences in incidence rates between whites and blacks.[25] In addition, differences in access to and the use of health care services, in addition to the quality of treatment, have been shown to contribute to disparities in outcomes of lung cancer.[26,27] In a recent study, fatalistic beliefs including the concern that radiation exposure from a computed tomography (CT) scan could cause lung cancer and anxiety related to CT scans were reported to be strongly associated with a decrease in the intention to undergo screening among black and Hispanic adults in comparison with nonminority adults.[28]

Histology

Lung cancer refers to a group of cancers that form in the lung; different types have traditionally been distinguished by the differences in the morphologic appearance observed under a light microscope. Genetic and genomic criteria are needed to better understand and predict the varying biologic behavior of the different types.[29] Often in public health statistics, nearly all lung cancer is presented as 2 categories: non–small cell carcinoma (85% of the total lung cancer cases) and small cell carcinoma (14%).[2] Non–small cell carcinomas are further classified as adenocarcinoma (41% of the total lung cancer cases), squamous cell and transitional cell carcinoma (21%), large-cell carcinoma (3%), and non–small cell not otherwise specified (20%).[2] Data from selected cancer registries in the 1960s and 1970s showed an increase in the rates of adenocarcinoma, and by the 1980s adenocarcinoma had become more common than squamous cell carcinoma among both men and women.[30] The incidence of small cell lung cancer has decreased over time; whereas 73% of cases of small cell lung cancer were initially in men, the male-to-female ratio is now 1:1.22.[31] Details on the histology of lung cancer are important considerations for its clinical management. For example, surgical resection is the primary treatment for stage I and II non–small cell lung cancer in patients with small surgical risk.[32] By contrast, localized-stage small cell lung cancer is treated with concurrent chemoradiotherapy.[33]

ETIOLOGY

Tobacco

Cigarette smoking is the major cause of lung cancer in the United States and worldwide.[34–36] During the period 2005 to 2009 in the United States, excluding deaths from second hand smoke, 84% of annual deaths from lung cancer in men and 76% in women were attributed to cigarette smoking.[35] Only a fraction of smokers develop lung cancer in their lifetime and lung cancer can develop in non-smokers, indicating that other factors in addition to smoking play a role in its development.[18,37,38] The most effective preventive measures are to never start smoking or to stop cigarette smoking as soon as possible. In 2012, 18% (42 million) of United States adults aged 18 years upward were current cigarette smokers.[39] The risk of lung cancer increases with both the duration and intensity of smoking,[34] but the number of years smoked is a stronger predictor of lung cancer than the number of cigarettes smoked per day.[40]

Over the course of a lifetime, the risk of developing lung cancer can be 20 times or greater for smokers than for lifetime nonsmokers.[34] Smokers who quit smoking continue to have a higher risk than lifetime nonsmokers of developing lung cancer, but this risk diminishes over time.[38,41] More than half of all adult current smokers have attempted to quit for at least 1 day in the past year.[42] Charts to demonstrate the harms of cigarette smoking have been developed for use by physicians to discuss these issues with patients.[43] The charts show the 10-year risks of dying of lung cancer considering age, sex, and smoking status (current smoker, former smoker, and lifetime nonsmoker). The charts are available online in several formats, and can be posted in clinic offices for easy reference or distributed among patients.[43]

Secondhand Smoke

Secondhand smoke is the term used to describe sidestream smoke (the smoke released from the burning end of a cigarette) and exhaled mainstream smoke (the smoke exhaled by the smoker). Secondhand smoke is a recognized cause of lung cancer; however, the secondhand smoke-attributable mortality for lung cancer is 4%.[35] The increase over the background risk of lung cancer among nonsmokers living with a smoker has been estimated to be 20% to 30%.[35] According to data from the National Health and Nutrition Examination Survey, during 2007 to 2008 approximately 88 million nonsmokers aged 3 years or older in the United States were exposed to secondhand smoke. The prevalence of exposure was higher for children (aged 3–11 years) and youth (aged 12–19 years) than for adults aged 20 years or older.[35] During 2005 to 2009 in the United States, 7330 deaths from lung cancer were attributed to exposure to secondhand smoke among nonsmokers.[35]

Radon

The US Environmental Protection Agency (EPA) publication "A Citizen's Guide to Radon" is an excellent resource for any questions about radon.[44] Selected highlights are as follows. Radon is a radioactive gas produced by the natural decay of uranium in soils, rocks, and water. Radon gas can seep into buildings through cracks in foundations, accumulate in indoor air, and thereby increase the risk of lung cancer for both smokers and nonsmokers.[45] In the United States, an estimated 1 in 15 American homes have high levels of radon. The EPA and the Surgeon General recommend testing all homes for radon. Test kits can be obtained from state radon programs, home improvement and hardware stores, and other sources.[44,46] Radon is measured in picocuries per liter of air (pCi/L). On average, radon levels are 0.4 pCi/L for outdoor air and 1.3 pCi/L for indoor air. The EPA recommends radon mitigation to 2 pCi/L or less if indoor air levels remain at least 4 pCi/L.[44] A certified or qualified radon contractor should design and install the radon-reduction system.[44] The design depends on the house, but a common example is a soil-suction system to prevent radon from entering the home, whereby a pipe system and fans are used to draw radon gas from below the home and vent it to the outside.[44]

Occupational Exposures

Many chemical and physical agents have been demonstrated to cause lung cancer among working populations. Some of the most frequently mentioned occupational lung carcinogens include asbestos, beryllium, cadmium, chloromethyl ethers, chromium (hexavalent, hereafter abbreviated VI), nickel, diesel exhaust, radon, and silica.[36,47] Industries with higher levels of exposure to lung carcinogens include mining, construction, manufacturing, agriculture, and certain service sectors. The number of adult workers in the United States exposed to carcinogens at work has been estimated to be many millions.[48] Tens of thousands of chemicals used in industries have never been evaluated for their carcinogenicity, and many of these chemicals are found in the general environment and consumer products.[48] Special occupational standards have been established for only a relatively small number of lung carcinogens, including asbestos, arsenic, chromium(VI), cadmium, and formaldehyde.[49] These standards were established after lengthy regulatory proceedings that considered many factors in addition to the health risk, including the feasibility of controlling the exposures and limits in the monitoring technology.

Outdoor Air Pollution

The combustion of fossil fuels by motor vehicles and other sources releases fine particulate matter, diesel exhaust, and other pollutants into the atmosphere. A growing body of evidence links outdoor air pollution with increased rates of lung cancer in the general population.[50,51] In 2013, the International Agency for Research on Cancer (IARC), a special agency of the World Health Organization, classified outdoor air pollution as carcinogenic to humans and found sufficient evidence to conclude that exposure to outdoor air pollution causes lung cancer.[52] Particulate matter, a major component of outdoor air pollution, was evaluated separately and was also classified by the IARC as carcinogenic to humans. In 2007, 13.6% of the general United States population resided in counties that exceeded the air pollution standard for fine particles, and minority groups were more likely than whites to live in these areas.[53] In addition, an estimated 1.8 million tons of mobile sources of toxic emissions in the air were reported in 2005 in the United States; a Healthy People 2020 objective is to reduce this figure to 1 million tons.[54]

Additional Risk Factors

Several other factors are associated with the increased risk of lung cancer. Examples include family history of lung cancer; chronic obstructive lung disease; fibrotic lung disorders such as pneumoconiosis; and human immunodeficiency virus (HIV) infection.[36,55]

LUNG CANCER SCREENING TESTS

Computed Tomography Lung Examinations

LDCT tests (sometimes abbreviated as low-dose CT) can be used to screen individuals at high risk for lung cancer. The individual lies still on a table, and the LDCT scanner rotates around the individual as the table passes through the center of the scanner. The entire chest is scanned in about 7 to 15 seconds during a single breath-hold. The scanner may include more than 1 source of x-rays. The x-ray sources follow a path similar to a helix or spiral as they rotate around the patient (some publications use helix and others use spiral; these terms are interchangeable). Rows of detectors are used to capture the x-ray information corresponding to multiple cross sections (thin slices) of the lung. Computers can create images from the x-ray information and assemble the images into a series of 2-dimensional slices of the lung at very small intervals.

Additional evaluation is needed to confirm that lung cancer is present if an LDCT scan reveals a pulmonary nodule.[56–59] Pulmonary nodules with a low probability of cancer may be followed with repeat LDCT screening over a period of time for growth-rate evaluation.[13] For nodules with a moderate probability of lung cancer, higher-dose diagnostic LDCT scans are often used in combination with positron emission tomography scans to evaluate the possibility of cancer metastasis. Biopsies may also be obtained. Depending on the results, patients are further evaluated for treatment.

A national consensus has not yet been developed for a standardized reporting system for lung cancer screening with LDCT equivalent to the Breast Imaging Reporting and Data System for mammography reporting.[60] A Lung Reporting and Data System equivalent has been proposed.[7]

National Surveys of Practice Patterns

Recent national survey information on lung cancer screening is limited. In a national survey of 962 practicing primary care physicians in 2006/2007, 55% had ordered chest radiography for lung cancer screening and 22% had ordered LDCT scans.[61,62] In the 2010 National Health Interview Survey, 2.5% of adults reported undergoing chest radiography in the prior year to check for lung cancer, and 1.3% reported undergoing chest CT to check for lung cancer.[63]

National Lung Screening Trial

The National Lung Screening Trial (NLST) was a randomized controlled trial to compare the effects of helical LDCT and standard chest radiography on the death rates for lung cancer among individuals at high risk for lung cancer in the United States.[64,65] The NLST was conducted at 33 locations and enrolled 53,454 adults starting in 2002. Eligible participants were between 55 and 74 years of age at the time of randomization with a history of cigarette smoking of at least 30 pack-years, and former smokers if they had quit within the previous 15 years. Half of the participants were randomly assigned to lung cancer screening with LDCT, and the other half to screening with single-view posteroanterior chest radiography. Subjects were screened annually for 3 years. In 2011, the NLST reported a 20% reduction in mortality from lung cancer among individuals screened by LDCT when compared with individuals screened by chest radiography.[65] Table 1 summarizes selected NLST benefits and harms. The benefits of lung LDCT screening for reducing deaths from lung cancer was greater among older, heavier smokers who greatly exceeded the minimum eligibility requirements for screening than among younger, less heavy smokers closer to the minimum eligibility requirements.[66,67] Two annual LDCT screenings resulted in a decrease in the number of advanced-stage cancers diagnosed and an increase in the number of early-stage lung cancers diagnosed.[68]

Cancer Intervention and Surveillance Modeling Network

The Cancer Intervention and Surveillance Modeling Network (CISNET) used data from the NLST and the Prostate, Lung, Colorectal, and Ovarian Cancer Screening trial to compare multiple scenarios of lung cancer screening.[69] All scenarios followed a cohort of 100,000 persons aged 45 to 90 years until death from any cause. Variations included the frequency of screening (annual, every 2 years, or every 3 years); age to begin screening (age 45, 50, 55, or 60 years); age to end screening (age 75, 80, or 85 years); minimum pack-years for screening eligibility (10, 20, 30, or 40 years); and maximum years since quitting for screening eligibility (10, 15, 20, or 25 years). Five models, developed by investigators at 5 different institutions, were used in the analyses, and estimates were averaged across the 5 models. CISNET analyses of the number of deaths from lung cancer included 7.5 years of follow-up compared with the 6.5 years in the NLST. With the additional year, the estimated lung cancer–specific reduction in mortality was 14%, rather than the 20% reduction reported in 2011 by the NLST. Annual screening resulted in the greatest reduction in mortality (11%–21% reduction), in comparison with biennial screening (6.5%–9.6% reduction) and triennial screening (≤6% reduction). The CISNET modelers concluded that the optimal balance of benefits and harms would be provided by starting annual screening at age 55 years, and ending screening at the age of 80 years for smokers with at least 30 pack-years and for former smokers no more than 15 years since quitting.[69] The CISNET identification code for this scenario was A55-80-30-15. Table 2 summarizes selected benefits and harms for this scenario projected by CISNET.

Overdiagnosis of lung cancer is defined as the detection of indolent lung cancer that would not have become clinically apparent.[70] Overdiagnosis is possible using lung cancer screening with LDCT, but estimates of the frequency have varied. The NLST Overdiagnosis Writing Team estimated the upper bound on the probability of overdiagnosis to be 18.5% (95% confidence interval 5.4%–30.6%) for cases identified by LDCT screening.[70] The CISNET modelers estimated overdiagnosis to be present in 9.9% of all screen-detected cases for scenario A55-80-30-15.[69]

European Studies

In Europe, several randomized controlled trials are in various stages of progress.[71–76] In general, compared with the NLST, the European trials have studied a smaller number of subjects and have used different screening intervals, numbers of rounds, and methods. For example, some of the European studies have used 3-dimensional scans in addition to 2-dimensional scans. Moreover, volume-doubling time is being used in some European trials to assess change in nodule size over time between 2 scans.[77] The probability that a nodule is malignant is low if the volume-doubling time is 400 days or more.[77,78]

SCREENING RECOMMENDATIONS

Task Force Recommendation

In 2013, the US Preventive Services Task Force (Task Force) recommended "annual screening for lung cancer with low-dose computed tomography in adults ages 55 to 80 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years."[79,80] The Task Force also recommended that "screening should be discontinued once a person has not smoked for 15 years or develops a health problem that substantially limits life expectancy or the ability or willingness to have curative lung surgery."[79,80] Approximately 10 million people in the United States would qualify for lung cancer screening with LDCT based on these NLST age and smoking criteria.[63]

Recommendations of Others

Many organizations in the United States updated their recommendations on lung cancer screening following the 2011 NLST report (Table 3).[81–86] Although differences exist between organizations, many recommend eligibility criteria similar to those of NLST; they also recommend smoking cessation services or referral, and performance of screening in facilities with access to multispecialty expertise for follow-up management.

ORGANIZATIONAL CHARACTERISTICS THAT FACILITATE BEST PRACTICE

Structured Screening Program

In the section labeled “Other Considerations,” the Task Force’s 2013 recommendation statement encourages standardization of LDCT screening and the follow-up of abnormal findings, and the development of a registry to collect the data needed to enable continuous improvement in screening program quality over time.[80] Several organizations in the United States have recommended that lung cancer screening and follow-up be conducted as part of a structured, high-volume, high-quality program including a multidisciplinary team skilled in the evaluation and treatment of lung cancer (Box 1).[81–86] A national consensus on the standards for structured programs does not exist at present; depending on the elements required, the availability of lung cancer screening services with LDCT might be limited to larger, urban health care markets, where specialists are more likely to practice.[87]

The Lung Cancer Alliance has published a National Framework for Excellence in Lung Cancer Screening and Continuum of Care.[88] The principles of this framework include: clear information on eligibility and risks and benefits; compliance with standards for best practices from the National Comprehensive Cancer Network and the International Early Lung Action Program; a multidisciplinary team for a coordinated continuum of care; comprehensive smoking cessation; reporting results expeditiously to patients and physicians; participation in outcome data collection; and providing information on how screened individuals can advance research.

The American College of Radiology (ACR) offers a Computed Tomography accreditation program that includes evaluation of personnel qualifications, equipment specifications, and quality control.[89] A searchable list of locations with ACR CT accreditation is available on the ACR Web site.[90] A practice guideline for radiologists is being developed by the ACR and the Society of Thoracic Radiology.[91] The American Lung Association has recommended that hospitals and screening centers establish ethical policies for advertising and promoting lung cancer screening services with LDCT.[85]

Quality Control

In its “Clinician Fact Sheet,” the Task Force states that the effectiveness of lung cancer screening depends on accurate interpretation of LDCT images and resolving most false-positive results without invasive procedures, in addition to limiting screening to people at high risk.[79] Consistent quality of LDCT images is critical to identifying abnormalities and tracking changes in suspicious findings over time while avoiding excessive exposure.[92,93]

Quality control and accreditation programs are needed to monitor the equipment performance and adherence to imaging protocols.[92,93] A centralized database may be helpful in identifying and flagging deviations from established protocols. In the NLST, quality assurance included a centralized review of a random sample of 1504 LDCT examinations. Quality defect rates ranged from 0% to 7.1%.[93]

Radiation Exposure and Dose

In the NLST, each LDCT resulted in an estimated effective dose of 1.5 millisievert (mSv) per examination.[64] In a 2013 survey of 15 academic medical centers in the United States, the average mean effective radiation dose for LDCT screening was reported as less than 1 mSv at 5 centers (33%), 1 to 2 mSv at 7 centers (47%), 2 to 3 mSv at 2 centers (13%); 1 respondent did not know the dose.[91]

At least 1 radiology journal no longer accepts research articles that describe radiation as “low dose” because improvement in LDCT technology continually decreases the amount of radiation exposure considered low dose.[94] As an alternative, the following measures were suggested: volume CT dose index, dose length product, a measure of patient dimensions (effective diameter), and size-specific dose estimate on a per-patient basis.[94]

Methods are needed to track both the amount of radiation exposure during an individual examination and the total cumulative dose received by an individual over time.[95] Development of a multidisciplinary committee to reduce the radiation dose, repeat rate, and variability in quality of the LDCT image at a medium-sized community hospital has been described.[96]

Follow-up of Abnormal Results

In the section titled “Other Considerations,” the Task Force’s 2013 recommendation statement supports the establishment of protocols for follow-up of abnormal results such as the clinical practice guidelines in oncology for lung cancer screening by the National Comprehensive Care Network.[59] In the NLST, an LDCT screening examination was considered positive for potential lung cancer if there were noncalcified pulmonary nodules with a long-axis diameter of 4 mm or more in the axial plane.[97] Approximately 27% of initial screening examinations were positive.[97] Several different groups have developed recommendations for the follow-up management of solid and subsolid nodules (subsolid nodules are common with peripheral adenocarcinoma).[56–59] Many nodules are benign, but it may take 1 to 2 years to rule out cancer. The nodule size is one of the key decision parameters in the follow-up management algorithms. To reduce the number of false positives, increasing the minimum nodule size for positive results to 7 to 8 mm has been suggested.[98] Research is ongoing to accurately estimate the probability of a lung nodule detected by LDCT screening being malignant.[56,99,100]

SMOKING CESSATION

Smoking prevention and cessation remain the fundamental strategies to drastically reduce the number of cases of lung cancer in the United States and elsewhere. Several studies conclusively show that smoking cessation lowers the risks for lung cancer among smokers.[34,35,101] However, the risk for lung cancer remains greater in former smokers than in lifetime nonsmokers.[101,102]

A small number of studies have been conducted to determine whether lung cancer screening with LDCT increases the chances of smoking cessation or changes perceptions about quitting.[103–108] The limited available data seem to indicate that patients who receive LDCT screening, similarly to those who do not, have other factors that may better predict smoking cessation. For smokers, the factors associated with nicotine dependence at the time of the LDCT screening such as the number of cigarettes smoked per day and the time smoking the first cigarette in the morning, as well as other factors such as having 1 or more smoking-related diseases (eg, emphysema, chronic pulmonary obstructive disease), are likely to be better predictors of quit attempts and smoking cessation than receiving LDCT screening. For former smokers, the time passed since they last smoked a cigarette and having 1 or more smoking-related diseases are likely to be better predictors of relapse than receiving LDCT screening.

Under "Other Considerations," the 2013 Task Force recommendation statement indicates that lung cancer screening with LDCT should not be viewed as an alternative to tobacco cessation, and current smokers should be informed of their continued risk for lung cancer and be offered cessation treatments before referral.[80] A potential area for future research might be whether the expanded use of lung cancer screening with LDCT in community practice will be associated with increased attention to smoking cessation messages given by health professionals; in 2010, only 48.3% of adult smokers had been advised by a health professional to quit.[42] A smoking cessation message provided in a clear, strong, and personalized manner by a health professional increases abstinence by current smokers.[109] Former smokers, particularly those who have recently quit, may also potentially benefit from counseling that acknowledges the patient's success and addresses any problems associated with cessation; emphasizes the importance of continued abstinence when they are referred for lung cancer screening with LDCT; and underscores the availability of support to resume abstinence if they relapse.[109]

Information is available for physicians and other health care practitioners on how to help their patients quit smoking. The US Public Health Services 2008 update of the Clinical Practice Guideline on Treating Tobacco Use and Dependence[109] (hereafter referred to as the 2008 Tobacco Use Guideline) provides guidance on intervening with smokers who want to quit or who have recently quit, and includes motivational messages for those not currently willing to make an attempt to quit. Effective treatments include individual, group, and telephone counseling, as well as 7 medications approved by the Food and Drug Administration. The effectiveness of the treatment increases with increasing intensity. Multiple counseling sessions are more effective than a brief single counseling session, and therapy combining counseling and medications is more effective than either component alone.

In addition to the proven strategies to encourage and support smoking cessation by health professionals, the 2008 Tobacco Use Guideline also points out that these strategies have not yet been fully implemented in health care settings, and that health care administrators, insurers, and purchasers have an important role to play in helping to ensure that tobacco use is systematically assessed and treated with evidence-based strategies at every clinical encounter.[109] Examples of potential interventions by the health care system include automated systems to identify smokers and an expanded insurance coverage of evidence-based treatment for tobacco use (both medication and counseling). The 2008 Tobacco Use Guideline also acknowledges that additional research would be helpful for specific population groups (eg, smokers who have low socioeconomic status and limited formal education).[109]

Quitting smoking at any age improves health, and reduces the risk of lung cancer and other diseases.[110,111] It is never too late to help patients to quit smoking. A Web site at the Centers for Disease Control and Prevention (http://www.cdc.gov/tobacco/campaign/tips/quit-smoking/) includes tips from former smokers and resources for smokers who are ready to quit, and the National Cancer Institute (NCI) Web site (www.smokefree.gov) includes practical cessation information as well as information on how to sign up for SmokefreeTXT, which is a mobile text-messaging program for help to quit smoking. In addition, the NCI has a toll-free number that connects smokers to their state quitline, which smokers can call to talk to a coach for help to quit smoking: 1-800-QUIT-NOW (1-800-784-8669) or, for assistance in Spanish, 1-855-DÉJELO-YA (1-855-335-3569) (Box 2).

INFORMED AND SHARED DECISION-MAKING DISCUSSIONS

In the section “Other Considerations,” the 2013 Task Force recommendation statement indicates that the decision to begin screening should be made through a shared decision-making process whereby patients and providers discuss the potential benefits, harms, and uncertainties of screening.[80] In its “Clinician Fact Sheet,” the Task Force provides potential discussion points for 3 patient scenarios: patients who fit all screening criteria; patients who are outside the screening criteria; and patients who fit all screening criteria but have a significant comorbid condition.[79]

Other organizations recommending lung cancer screening with LDCT also have suggested an informed and shared decision-making process before referral for screening.[81–86] Studies suggest that primary care providers need to tailor their approach to informed and shared decision making for each patient, for example by asking each patient for his or her input on the desired level of participation.[112,113] Patients vary in their preference for participation in the decision-making process, with some preferring an active or collaborative role and others favoring a passive role. A patient’s preference may also change over time, and a mismatch between patients’ preferred and actual roles is common.[112,113] A taxonomy has been proposed to categorize the harms that might occur during lung cancer screening with LDCT, including physical harms, psychological harms, financial strain, and opportunity costs.[114]

Higher-Risk Individuals

Tables 4 and 5 list selected examples of potential items for consideration during informed and shared decision-making discussions with patients, organized according to the Task Force’s previously suggested “5 As” framework: assess, advise, agree, assist, and arrange.[115] One of the more important topics to be addressed is that lung cancer screening with LDCT may involve a process over an extended period of time, rather than a single scan.[83,116] For example, after a pulmonary nodule is identified, evaluation to determine whether the nodule is benign or malignant may require additional CT scans, more invasive procedures, additional cost, and follow-up for 1 to 2 years.[116] The informed and shared decision-making discussion needs to occur before referral to LDCT screening, because many patients might assume that they have cancer when told that the LDCT scan has revealed a nodule.[116] Patients with significant comorbid conditions should be informed that they may be at greater risk for harm with screening,[79] and screening is not recommended if the comorbid conditions substantially limit life expectancy or the ability to undergo curative lung surgery.[80]

Lower-Risk Individuals

Primary care providers need to be prepared to answer questions about lung cancer screening with LDCT from individuals who do not meet the criteria for lung cancer screening with LDCT. Several examples include heavy smokers who are younger than the recommended age to begin screening, current or former smokers with fewer pack-years of smoking, individuals with other risk factors for lung cancer (eg, chronic obstructive lung disease), and healthy adults who have never smoked.[79] In its “Clinical Fact Sheet” scenarios, the Task Force recommends that health providers inform patients in lower risk categories about the potential harms of screening and that there is not enough evidence to recommend screening for individuals at lower risk for lung cancer.[79] The American Cancer Society also recommends informing individuals in lower risk categories that screening is not recommended at this time because there is too much uncertainty regarding the balance of benefits and harms (Box 3).[82]

HEALTH CARE CHANGES

Reimbursement for Grade A or B Preventive Services

The Patient Protection and Affordable Care Act requires most health insurance plans to cover preventive services at no additional cost to the patient if the Task Force grades the preventive service recommendation as A (strongly recommended) or B (recommended).[117] Both tobacco cessation (graded A) and lung cancer screening with LDCT (graded B) would qualify for insurance coverage at no additional cost.

Patient-Centered Medical Home

The patient-centered medical home is a model to improve the delivery of primary care by greater involvement of the patient in care plans, coordinated and comprehensive team-based care, improved patient access to care after hours and by e-mail and phone, and a commitment to quality improvement and population health management.[118] In the context of lung cancer screening with LDCT, the primary care patient-centered medical home will remain important even if the primary care provider refers patients to a structured program that offers lung cancer screening and follow-up management. Several examples of potential activities for the primary care provider include identification of patients eligible for lung cancer screening with LDCT, informed and shared decision-making discussions with patients before referral, promotion of smoking cessation, management of comorbid conditions that are not addressed by specialists, and eliminating barriers to timely care.[119,120]

Electronic Health Records

If electronic health records (EHRs) include information on patient age and pack-years of smoking, EHRs may be used to identify individuals who meet the eligibility criteria for lung cancer screening with LDCT. Computer algorithms may be designed to use with EHRs to provide patients with cellphone reminders about the need to schedule their annual lung cancer screening with LDCT and the importance of smoking cessation.[121,122] An integrated system of EHRs may also facilitate the retrieval of information from multiple providers to evaluate the performance and quality of a lung cancer screening program with LDCT, notify the responsible clinicians about abnormal imaging results that need follow-up, and improve the early recognition of patients with lung cancer.[121,122]

Accountable Care Organizations

The Patient Protection and Affordable Care Act encourages groups of providers to collaborate, manage, and coordinate the care of patients through accountable care organizations (ACOs).[117] ACOs that meet quality performance standards are eligible to receive payments for shared savings. Bekelman and colleagues[123] have suggested that cancer specialists in larger, urban health care markets may want to develop Cancer Care Groups to provide guideline-concordant, patient-centered, coordinated care among cancer specialists and primary care providers. Activities related to lung cancer screening with LDCT would seem reasonable for ACOs to consider, especially if lung cancer screening with LDCT and follow-up is managed as part of a structured program with a multidisciplinary team.

SUMMARY

Annual LDCT screening for lung cancer cannot prevent lung cancer, but can reduce mortality from lung cancer in persons at high risk based on the age and smoking history of the individual. Lung cancer screening can supplement, but not replace, efforts to address the primary prevention of lung cancer through the control of tobacco and other known risk factors associated with lung cancer. Considerations for primary care providers may include the resources available in their communities for lung cancer screening with LDCT and for smoking cessation, and the key points that need to be addressed in the informed and shared decision-making discussions with patients. Lung cancer screening with LDCT is a rapidly evolving area. Examples of upcoming areas of potential importance may include the following: decisions from Centers for Medicare and Medicaid Services about reimbursement and billing codes; ACR recommendations on quality control and reporting of LDCT findings; results from additional analyses of the NLST data; results from European studies, especially on the use of volume-doubling time to evaluate whether pulmonary nodule sizes have changed over time; and whether a national consensus can be developed with standard algorithms for patient management.

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KEY POINTS

- The US Preventive Services Task Force recommends annual low-dose computed tomography (LDCT) screening for lung cancer for persons at high risk for lung cancer, based on the age and smoking history of the individual.
- Lung cancer screening with LDCT does not prevent lung cancer, nor does it eliminate the need to extend smoking cessation referral and support to current smokers screened for lung cancer.
- Several organizations have recommended that lung cancer screening with LDCT be conducted as part of structured, high-volume, high-quality programs by a multidisciplinary team skilled in the evaluation and treatment of lung cancer.
- It is important for primary care providers to know the resources available in their communities for lung cancer screening with LDCT and smoking cessation, and the key points to be communicated to patients for informed and shared decision-making discussion about lung cancer screening.

Box 1

Structured lung cancer screening

Formal program

Access to a multidisciplinary clinical team and clinical resources to provide diagnosis, follow-up treatment, and long-term patient management related to lung screening

Patient eligibility criteria consistent with Task Force recommendations

Informed and shared decision-making discussions before initial screening

Smoking cessation program

American College of Radiology certification in computed tomography

Staff and resources for data collection to monitor program quality

Participation in American College of Radiology data registry program

Box 2

Resources for smoking cessation

Resources for Patients

Anyone can reach the state tobacco quitline by calling 1-800-QUITNOW

Support for quitters

http://www.smokefree.gov

http://www.cdc.gov/tobacco/quit_smoking/index.htm

Tips from former smokers

http://www.cdc.gov/tobacco/campaign/tips/index.html

Resources for Clinicians and Other Health Providers

Treating tobacco use and dependence

http://www.ahrq.gov/professionals/clinicians-providers/guidelines-recommendations/tobacco/clinicians/presentations/2008update-overview/index.html

Charts that show the 10-year risks of dying from lung cancer

http://jnci.oxfordjournals.org/content/100/12/845/suppl/DC1

Telephone quitlines

http://www.cdc.gov/tobacco/quit_smoking/cessation/quitlines/index.htm

Box 3

Resources for patients about lung cancer screening

American Cancer Society. Patient Page. Testing for lung cancer in people at high risk. CA Cancer J Clin 2013;63(2):118–9. http://www.cancer.org/healthy/informationforhealthcareprofessionals/acsguidelines/lungcancerscreeningguidelines/index

American Lung Association. Lung cancer CT screening for early detection. One pager. http://www.lung.org/lung-disease/lung-cancer/lung-cancer-screening-guidelines/lung-cancer-onepager.pdf

American Lung Association. Provides guidance on lung cancer screening. Full Report. Appendix I. American Lung Association Toolkit. Making an individual decision to be screened. http://www.lung.org/lung-disease/lung-cancer/lung-cancer-screening-guidelines/

National Cancer Institute. Patient and physician guide: National Lung Screening Trial. http://www.cancer.gov/newscenter/qa/2002/NLSTstudyGuidePatientsPhysicians

National Cancer Institute. Lung cancer screening (PDQ). Patient version. http://www.cancer.gov/cancertopics/pdq/screening/lung/Patient/page1/AllPages

National Comprehensive Cancer Network. NCCN guidelines for patients. Lung cancer screening. Version 1. 2014. http://www.nccn.org/

National Framework for Excellence in Lung Cancer Screening and Continuum of Care. Lung Cancer Alliance. http://www.lungcanceralliance.org

US Preventive Services Task Force. Consumer fact sheet. Understanding Task Force recommendations. Screening for lung cancer. http://www.uspreventiveservicestaskforce.org/adultrec.htm

Table 1

Selected benefits and harms of lung cancer screening reported by the National Lung Screening Trial for all 3 rounds, comparing low-dose computed tomography (LDCT) with chest radiography[a]

	LDCT	**Chest Radiography**
Participants		
No. of participants	26,722	26,732
Adherence to 3 rounds of screening	95%	93%
Person-years	144,103	143,368
Benefits		
Lung cancer deaths	356	443
Rate of death from lung cancer per 100,000 person-years	247	309
Relative reduction in mortality from lung cancer with LDCT	62/309 = 20%	—
Risk of Harms		
Percentage of tests classified as positive	24.2%	6.9%
Percent of positive results that were false positives	96.4%	94.5%
Rate of at least 1 complication after the most invasive screening related diagnostic procedure[b]	1.4%	1.6%
Percentage of positive screening tests associated with a major complication from invasive screening related diagnostic procedures[b] when:		
Lung cancer not diagnosed	0.06%	0.02%
Lung cancer diagnosed	11.2%	8.2%
Deaths within 60 d after the most invasive screening-related diagnostic procedure[b]	16	10

[a]The NLST conducted screening from August 2002 to September 2007, and followed up the participants through December 31, 2009. Analysis of the number of deaths from lung cancer includes deaths that occurred from the date of randomization through January 15, 2009 (6.5 years' follow-up).

[b]Invasive procedures include mediastinoscopy or mediastinotomy, thoracoscopy, or thoracotomy.

Data from National Lung Screening Trial Research Team, Aberle DR, Adams AM, et al. Reduced lung-cancer mortality with low-dose computed tomographic screening. N Engl J Med 2011; 365(5):395–409.

Table 2

Selected benefits and harms of lung cancer screening with annual low-dose computed tomography (LDCT) screening reported by the Cancer Intervention and Surveillance Modeling Network

Screening Scenario	
Scenario identification code	A55-80-30-15
Frequency of screening	Annual
Smoking requirement	Ever-smokers with at least 30 pack-years, and no more than 15 y since quitting for former smokers
Start screening at age	55 y
End screening at age	80 y
Study Cohort	
Cohort size	100,000 persons
Cohort age range	45–90 y
Proportion of cohort that receive screening[a]	19%
Benefits	
Lung cancer detected at an early stage (stage I or II)	50.5%
Lung cancer mortality reduction[b]	14.0%
Lung cancer deaths averted	521
Harms	
Total no. of screenings with LDCT	286,813
No. of overdiagnosed cases[c]	190
Overdiagnosis, % of all cases[c]	3.7%
Overdiagnosis, % of screening detected cases[c]	9.9%
No. of lung cancer deaths related to radiation exposure	24
LDCT scans per lung cancer death averted	550

[a]The Cancer Intervention and Surveillance Modeling Network (CISNET) assumed that only eligible persons (19%) in the cohort were screened, whereas the NLST screened almost all enrolled persons in the LDCT arm.

[b]CISNET analysis of the number of deaths from lung cancer included 7.5 years of follow-up compared with the 6.5 years of follow-up reported in the National Lung Screening Trial.

[c]Overdiagnosis refers to slow-growing or indolent lung cancers.

Data from de Koning HJ, Meza R, Plevritis SK, et al. Benefits and harms of computed tomography lung cancer screening strategies: a comparative modeling study for the US Preventive Services Task Force. Ann Intern Med 2013; http://dx.doi.org/10.7326/M13-2316.

Table 3

Lung cancer screening recommendations

Organization	Groups Eligible for Screening	Year
American Association for Thoracic Surgery[81]	**1** Age 55–79 y with ≥30 pack-year smoking history **2** Long-term lung cancer survivors who have completed 4 y of surveillance without recurrence, and who can tolerate lung cancer treatment to detect second primary lung cancer until the age of 79 y **3** Age 50–79 y with a 20 pack-year smoking history and additional comorbidity that produces a cumulative risk of developing lung cancer ≥5% in 5 y	2012
American Cancer Society[82]	Age 55–74 y with ≥30 pack-year smoking history, either currently smoking or have quit within the past 15 y, and who are in relatively good health	2013
American College of Chest Physicians[83]	Age 55–74 y with ≥30 pack-year smoking history and either continue to smoke or have quit within the past 15 y	2013
American College of Chest Physicians and American Society of Clinical Oncology[84]	Age 55–74 y with ≥30 pack-year smoking history and either continue to smoke or have quit within the past 15 y	2012
American Lung Association[85]	Age 55–74 y with ≥30 pack-year smoking history and no history of lung cancer	2012
National Comprehensive Cancer Network[86]	**1** Age 55–74 y with ≥30 pack-year smoking history and smoking cessation <15 y **2** Age ≥50 y and ≥20 pack-year smoking history and 1 additional risk factor (other than secondhand smoke)[a]	2012
US Preventive Services Task Force[79,80]	Age 55–80 y with ≥30 pack-year smoking history and smoking cessation <15 y	2013

[a] Additional risk factors include cancer history, lung disease history, family history of lung cancer, radon exposure, occupational exposure, and history of chronic obstructive pulmonary disease or pulmonary fibrosis. Cancers with increased risk of developing new primary lung cancer include survivors of lung cancer, lymphomas, cancer of the head and neck, and smoking-related cancers. Occupational exposures identified as carcinogens targeting the lungs include silica, cadmium, asbestos, arsenic, beryllium, chromium(VI), diesel fumes, and nickel.

Table 4

Selected examples of items to be considered in informed and shared decision-making discussions about screening for cancer with low-dose computed tomography (LDCT)

Steps	Components
Assess	*Availability:* Is an organized, high-volume, high-quality lung cancer screening program available with a multidisciplinary team skilled in lung cancer evaluation and treatment? *Eligibility:* Does the patient meet lung screening eligibility criteria? *Time:* Is time available for informed and shared decision-making discussions with the patient? *Knowledge:* What is the patient's level of knowledge about lung cancer and lung cancer screening? What is the patient's literacy level? *Preferences:* Does the patient prefer an active, shared, or passive role in the decision-making discussions?
Advise	*Purpose:* Annual LDCT screening can detect lung cancer at an early stage in asymptomatic high-risk individuals. Lung cancer screening should be thought of as a process rather than a single test *Smoking cessation:* Current smokers should STOP SMOKING. Screening should not be viewed as an alternative to smoking cessation. Avoiding cigarettes can lower the risk of lung cancer, emphysema, heart disease, and vascular disease *Benefits:* LDCT may reduce the risk of dying from lung cancer in heavy smokers. For individuals meeting the minimum eligibility requirements, benefits of screening are greater in individuals who have been heavier smokers *Harms:* There is a significant chance of false alarms (false positives) with LDCT screening. Repeat testing over 1–2 y may be required to evaluate if a screen detected abnormality increases in size. In some cases, an invasive procedure (eg, needle biopsy, bronchoscopy, or thoracotomy) is needed to determine whether the abnormality is lung cancer. Invasive diagnostic procedures may result in major complications, and are more common in patients who have lung cancer. Death within 60 d has occurred after an invasive diagnostic procedure, but is rare *Radiation exposure:* Provide estimated radiation exposure for your location with 1 LDCT lung screening scan, and the cumulative lifetime total radiation with repeat annual screening *Patient costs:* How much does the patient need to pay for a scan? What is the cost of patient copayments for follow-up consultations and procedures? *Scientific uncertainties:* Negative screening results do not absolutely rule out the chance for lung cancer incidence. LDCT will not detect all lung cancers or all lung cancers early, and not all patients who have a lung cancer detected by LDCT will avoid death from lung cancer *Research:* How can screened individuals donate images and biospecimens to advance research in the prevention, diagnosis, and treatment of lung cancer? *Alternatives:* LDCT is the only screening test shown to lower the chances of dying of lung cancer. Chest radiography should not be used for lung cancer screening

Table 5

Informed and shared decision-making discussions

Steps	Components
Agree	Provider needs to help individuals clarify their preferences and willingness to be screened *Decide to screen with LDCT every year* Individual assigns higher value to potential benefits than to potential harms *Decide against LDCT screening:* Individual assigns higher value to potential harms than to the potential benefits
Assist	*Costs:* Help individuals determine if they have to pay for the initial LDCT scan and how much *Referral:* Provider identifies screening facilities with appropriate expertise, refers individual for screening, and informs individual how to schedule the screening test or that the screening clinic will contact the individual
Arrange	*Smoking cessation:* Provider should provide smoking cessation or refer current smokers to smoking cessation programs *Results:* How and when will the LDCT results be communicated to patients? *Follow-up* When will the informed-shared decision-making process about LDCT screening be revisited in the future?
Update	*Preferences and decisions* Assess any change over time in patient preferences and decisions before referral for the next annual LDCT screening
Document	*Documentation* Clearly document the informed and shared decision-making process and decisions to safeguard against potential medicolegal consequences (eg, if a case of lung cancer is detected before a decision has been made about lung cancer screening; or if the individual has major complications from lung cancer screening). Documentation may potentially need to cover more than 1 visit (eg, initial discussion with patient, follow-up discussions between patient and support staff, and educational materials provided to patient)